ISOLATED LOW-VOLTAGE POWER SUPPLY SOURCE

PRIORITY CLAIM

[1] This application claims priority from French patent application No. 02/16806, filed December 27, 2002, which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[2] The present invention relates to a power supply source of a relatively low D.C. voltage to a circuit for controlling a switch or a load supplied by a relatively high voltage. The present invention more specifically relates to the supply of a high-voltage load control circuit upstream of a rectifying bridge, for example, providing a rectified voltage to a power converter of switched-mod power supply type.

DISCUSSION OF THE RELATED ART

[3] **FIG. 1** very schematically shows in the form of blocks a first conventional example of provision of a relatively low supply voltage to a control circuit ***1***, in this example, via a switch ***K***, of a load ***2*** (***Q***) supplied by a relatively high A.C. voltage Vac applied between terminals ***P*** and ***N***. Terminals ***P*** and ***N*** correspond to A.C. input terminals of a fullwave rectifying bridge ***3*** having rectified output terminals ***E*** and ***M*** supplying a power converter ***4*** (***CONV***), for example, of switched-mode power supply type. In the example of **FIG. 1**, converter ***4*** provides several D.C. voltages of different levels (for example, two voltages ***Vs1*** and ***Vs2***) referenced to a ground ***G*** that may be different from output ground ***M*** of bridge ***3***.

[4] The supply voltage of control circuit ***1*** is, for example, provided by a supply block ***6*** itself supplied from a voltage ***Vsaux*** provided by converter ***4*** by means of an auxiliary winding.

[5] A problem is that the winding of provision of voltage ***Vsaux*** must be referenced to neutral ***N*** of the A.C. power supply, which must thus be isolated from ground ***G*** of the other output voltages of converter ***4***. This need for isolation within the actual converter ***4***, linked to the presence of an auxiliary winding referenced to the A.C. network, increases the converter complexity and bulk.

[6] Further, the auxiliary winding alters the coupling and increases leakage inductances of the converter.

[7] **FIG. 2** shows a second conventional example of provision of a supply voltage to a control circuit ***1*** of a load ***2*** supplied by an A.C. voltage ***Vac***. It shows fullwave rectifying bridge ***3*** and a converter of switched-mode power supply type ***4'***. The essential difference with respect to **FIG. 1** is that the example of **FIG. 2** uses a high-voltage capacitor ***CX*** upstream of rectifying bridge ***3*** rather than an auxiliary winding of converter ***4'***. Capacitor ***CX*** is connected by one of its electrodes to phase ***P*** of the A.C power supply and by the other one of its electrodes to a resistor ***R*** in series with a diode D and a capacitor C providing the supply voltage of circuit 1. A zener diode ***DZ*** is connected between the junction point of resistor ***R*** and diode ***D***, and neutral ***N*** of the A.C. power supply. Zener diode ***DZ*** sets the value of the voltage across capacitor ***C***, and thus of the low supply voltage of circuit ***1***. Diode ***D*** is used as a rectifying element, capacitor ***C*** being recharged one halfwave out of two of A.C. voltage ***Vac***, since diode ***DZ*** conducts forward via capacitor ***CX***.

[8] The example of **FIG. 2**, which actually consists of forming a high non-dissipative impedance in series with capacitor ***C*** of provision of the supply of control circuit ***1***, poses the same problems of size and cost as the example of **FIG. 1**.

SUMMARY OF THE INVENTION

[9] An embodiment of the present invention aims at providing a novel solution to supply, with a relatively low voltage, a control circuit of a load supplied by a relatively high voltage, generally an A.C. voltage, which overcomes the disadvantages of known solutions.

[10] In an application to a circuit comprising a power converter supplied by a rectifying bridge, the embodiment of the present invention more specifically aims at avoiding use of a specific auxiliary winding of the converter and at thus solving isolation problems, while drawing the supply power of control circuit ***1***, placed upstream of the rectifying bridge, downstream of said bridge.

[11] An embodiment of the present invention also aims at avoiding use of a high impedance upstream of the rectifying bridge.

[12] To achieve these and other objects, an embodiment of the present invention provides an isolated circuit of low-voltage supply of a control circuit of a high-voltage load, in or upstream of a rectifying bridge, comprising:

a first low-voltage capacitor having a first electrode connected to one of the rectified output terminals of the bridge; and

at least one second capacitor providing said low voltage, a first electrode of the second capacitor being connected to one of the A.C. input terminals of the bridge, the respective second electrodes of the capacitors being connected by a high-voltage diode having its cathode connected to the second capacitor.

[13] According to an embodiment of the present invention, the charge of the second capacitor occurs during a conduction period of the bridge when that of its rectifying elements which connects the respective first electrodes of the capacitors conducts, this element connecting the electrodes having the most negative potential.

[14] According to an embodiment of the present invention, the first capacitor is a capacitor of low-voltage supply of a circuit downstream of the bridge.

[15] According to an embodiment of the present invention, the circuit comprises a second high-voltage diode having its anode connected, via a logic-control switch, to the second electrode of the first capacitor, and having its cathode connected to a logic input terminals of the control circuit upstream of the bridge.

[16] According to an embodiment of the present invention, the rectifying bridge is a fullwave or three-phase bridge.

[17] According to an embodiment of the present invention, the bridge is a composite or controlled bridge.

[18] According to an embodiment of the present invention, said load is formed of at least one of the rectifying elements of the bridge.

[19] According to an embodiment of the present invention, the first capacitor is charged by an auxiliary winding of a transformer of a switched-mode power supply downstream of the bridge.

[20] The foregoing objects, features, and advantages will be discussed in detail in the following non-limiting description of specific embodiments in connection with the accompanying drawings.

Brief Description of the Drawings

[21] **FIG. 1**, previously described, schematically shows in the form of blocks a first conventional example of an isolated low-voltage supply circuit;

[22] **FIG. 2**, previously described, schematically shows in the form of blocks a second conventional example of an isolated low-voltage supply circuit;

[23] **FIG. 3** schematically shows in the form of blocks an embodiment of an isolated low-voltage supply circuit according to an embodiment of the present invention;

[24] **FIG. 4** shows an alternative embodiment of an isolated low-voltage supply circuit according to the present invention, adapted to providing a logic reference value to the supplied circuit; and

[25] **FIG. 5** shows another embodiment of an isolated supply circuit, dedicated to a controllable bridge.

Detailed Description

[26] Same elements have been referred to with same reference numerals in the different drawings. For clarity, only those elements which are necessary to the understanding of the present invention have been shown in the drawings and will be described hereafter. In particular, the present invention will be described hereafter in relation with an example of application to a bridge for supplying a converter of switched-mode power supply type. It should however be noted that the present invention more generally applies whatever the elements connected downstream of the fullwave or three-phase rectifying bridge, provided that a low-voltage capacitor is available therein. Further, the structure of the power converter of switched-mode power supply type has not been detailed and is no object of the present invention.

[27] An embodiment of the present invention uses a capacitor storing a relatively low voltage downstream of the fullwave or three-phase rectifying bridge to supply a capacitor, arranged upstream of the rectifying bridge and intended to

provide the supply of the isolated low-voltage control circuit. According to this embodiment of the present invention, the two capacitors are connected by a high-voltage diode providing the isolation.

[28] Another embodiment of the present invention uses one of the diodes (or more generally one of the rectifying elements) of the fullwave or three-phase bridge to close the charge circuit of the capacitor placed upstream of the bridge. On this regard, this embodiment of the present invention uses this rectifying element integrated to the bridge, in forward conduction, only when it conducts to ensure the power transfer to the power converter downstream of the bridge.

[29] **FIG. 3** schematically shows in the form of blocks an embodiment of an isolated low-voltage supply circuit ***10*** according to the present invention. Circuit ***10*** is intended to provide a voltage ***V*** for supplying a control circuit ***1*** (***CTRL***) of a high-voltage load ***2*** (***Q***). In the example of **FIG. 3**, circuit ***1*** controls a switch ***K*** placed in series with load ***2*** between two terminals ***P*** and ***N*** of application of an A.C. voltage ***Vac***. A fullwave rectifying bridge ***3*** has its A.C. inputs connected to terminals ***P*** and ***N*** and provides a rectified high voltage to a converter ***4' CONV*** of switched-mode power supply type similarly to the conventional example of **FIG. 2**. In **FIG. 3**, a high-voltage capacitor ***CHT*** has been shown between rectified output terminals ***E*** and ***M*** of bridge ***3***. Capacitor ***CHT*** is intended to store the capacitor supply voltage. Bridge ***3*** is in this example formed of four diodes ***D1*** to ***D4***, diodes ***D1*** and ***D3***, as well as diodes ***D2*** and ***D4*** being in series between terminals ***E*** and ***M***. The anodes of diodes ***D1*** and ***D2*** are respectively connected to terminals ***P*** and ***N***.

[30] According to this embodiment of the present invention, circuit ***10*** essentially comprises:

a capacitor ***C1*** downstream of bridge ***3***, having one of its electrodes connected to one of the rectified output terminals of the bridge (here, terminal ***M***), and thus to the common anodes of the rectifying elements;

at least one capacitor ***C2*** for providing voltage ***V***, placed upstream of bridge ***3*** and having one of its electrodes connected to one of the A.C. input terminals (here, terminal ***N***) of bridge ***3***; and

a diode ***Dr*** (or more generally a rectifying element) connecting the second respective electrodes of capacitors ***C1*** and ***C2***, the anode of diode ***Dr*** being connected to the capacitor electrode downstream of bridge ***3***.

[31] According to this embodiment of the present invention, capacitors ***C1*** and ***C2*** are both low-voltage capacitors. Diode ***Dr*** plays the role of an isolation barrier on the second (positive) electrodes of the capacitors while a diode (here, ***D4***) of bridge ***3*** plays the role of an isolation barrier between the first capacitor electrodes (the grounds).

[32] This embodiment of the present invention takes advantage of the presence in bridge ***3*** of diode ***D4***. However, said diode is not used like in its normal operation within the bridge. Indeed, for the charge of high-voltage capacitor ***CHT*** between terminals ***E*** and ***M***, forward diodes ***D1*** and ***D4*** are used for arbitrarily positive halfwaves and diodes ***D2*** and ***D3*** are used for negative halfwaves also when forward biased.

[33] According to this embodiment of the present invention, capacitor ***C2*** providing relatively low voltage ***V*** only charges by direct transfer of the power of capacitor ***C1*** by balancing the respective charges of capacitors ***C1*** and ***C2***. The only condition on bridge ***3*** is that this charge balance is performed during periods when diode ***D4*** conducts, that is, in the example, during charge periods of capacitor ***CHT*** on positive halfwaves. However, according to this embodiment of the present invention, diode ***D4*** is then not used to transfer the power in its forward direction.

[34] Indeed, when diode ***D4*** conducts, the voltage thereacross decreases and tends towards its junction voltage (for example, on the order of 0.6 volt). Then, if the voltage across capacitor ***C2*** is smaller than the voltage across capacitor ***C1***, diode ***Dr*** turns on and the voltages across capacitors ***C2*** and ***C1*** balance. Indeed, the voltage drops in diodes ***D4*** and ***Dr*** compensate for each other so that voltage ***V*** across capacitor ***C2*** corresponds to the voltage across capacitor ***C1***. In fact, the direction of diodes ***Dr*** and ***D4*** results in that capacitor ***C1*** recharges capacitor ***C2***. In fact, the current ensuring the charge of capacitor ***C2*** subtracts from the current corresponding to the power transfer to converter ***4'*** for its operation.

[35] The only precaution to be taken to implement this embodiment of the present invention is for capacitor ***C1***, if it must further supply elements of converter ***4'***, to be given a sufficient size to provide the power both for these elements and for control circuit ***1***. In other words, capacitor ***C1*** is sized according to the application to permanently provide a sufficient voltage.

[36] Preferably, capacitor ***C1*** downstream of bridge ***3*** corresponds to a capacitor used to supply a control circuit (not shown) of converter ***4*** (for example, the control circuit of the cut-off switch of this converter). In this case, this embodiment of the present invention takes advantage of the existence of a low-voltage capacitor downstream of the bridge to use the power stored by the latter to transfer this power onto capacitor ***C2*** upstream of the bridge.

[37] An advantage of this embodiment of the present invention is that it requires no additional auxiliary winding isolated from the other windings of converter ***4'***. The coupling of the transformer for providing low voltages by the converter is thus improved with respect to the case where one of the windings must be referenced to the neutral of the A.C. power supply. This embodiment of the present invention uses one of the existing windings (for example, that providing the supply voltage of the converter control circuit).

[38] Another advantage of this embodiment of the present invention is that it requires no high-voltage capacitor, be it upstream or downstream of the rectifying bridge.

[39] Another advantage of this embodiment of the present invention is that its implementation only requires, as compared to a conventional circuit of the type illustrated in **FIG. 2**, a slight oversizing of supply capacitor ***C1*** of the cut-off switch circuit to take into account the supply voltage necessary for circuit ***1*** upstream of the rectifying bridge.

[40] Of course, diode ***Dr*** is a high-voltage diode, to respect the need for isolation, diode ***D4*** being as for itself necessarily a high-voltage diode since it is already integrated in the bridge.

[41] **FIG. 4** shows an alternative embodiment of the present invention. This alternative consists of adding to a supply circuit of the type described in relation with

FIG. 3 a logic information transfer circuit between the circuit portion downstream of the rectifying bridge and control circuit ***1*** supplied by capacitor ***C2***. In this example, it has been considered that control circuit ***1*** was intended to turn off a switch ***K*** supplying, through capacitor ***C2***, the gate of a triac ***T*** in series with load ***2*** between terminals ***P*** and ***N***. Optionally, a resistor ***Rk*** (possibly confounded with switch ***K***) is interposed between the latter and the gate of triac ***T***.

[42] According to this alternative embodiment of the present invention, the control circuit receives a logic reference value ***LOG*** from a logic circuit ***11*** (***MCU***) downstream of rectifying bridge ***3***. For example, circuit ***11*** is a microcontroller having an output open-collector-assembled transistor ***B*** with its emitter connected to the positive electrode of capacitor ***C1*** and its base controlled by circuit ***11*** (in a way not shown).

[43] According to this alternative embodiment of the present invention, the collector of transistor ***B*** or any other equivalent element providing a logic level is connected, via an isolation diode ***Di***, to the input of circuit ***1*** receiving signal ***LOG***, which is further connected to ground (neutral ***N*** of the A.C. power supply) by a capacitor ***C3*** in parallel with a resistor ***Ri***. The function of capacitor ***C3*** is to temporarily store the logic signal control state, resistor ***Ri*** being there to have this signal disappear after some time (time constant defined by components ***C3*** and ***Ri***).

[44] Like for the supply of capacitor ***C2***, the logic reference value is transmitted from downstream to upstream of the rectifying bridge only when diode ***D4*** conducts and the isolation between the upstream and downstream portions of the rectifying bridge is guaranteed, for the control signal, by diodes ***Di*** and ***D4***.

[45] An advantage of the embodiment of **FIG. 4** is that it enables transferring a control reference value only by adding a high-voltage diode ***Di*** between the circuit portions downstream and upstream of a rectifying bridge supplying a converter.

[46] **FIG. 5** schematically and partially shows another embodiment of the present invention according to which the load to be controlled precisely is rectifying bridge ***13***. In this example, the bridge is a composite bridge in which, as compared to the previous drawings, diodes ***D3*** and ***D4*** have been replaced with two cathode-

gate thyristors ***Th3*** and ***Th4***. Downstream of bridge ***13***, same elements as those described in relation with the previous drawings are present, that is, a converter not shown and a low-voltage capacitor ***C1***.

[47] According to this embodiment of the present invention, capacitor ***C1*** is used to provide power to circuits ***11*** (***CT3***) and ***11'*** (***CT4***) for controlling thyristors, respectively ***Th3*** and ***Th4***, via two capacitors ***C2*** and ***C2'*** having an operation identical to that described in the preceding drawings for capacitor ***C2***. Each capacitor ***C2***, ***C2'*** is associated with a diode ***Dr***, ***Dr'*** connected downstream of bridge ***13*** on the positive electrode of capacitor ***C1***. Circuits ***11*** and ***11'*** are supplied by the respective voltages across capacitors ***C2*** and ***C2'***.

[48] Such an embodiment enables generating the power supply necessary to control the thyristors of the composite bridge.

[49] It should be noted that what has been described hereabove in relation with the thyristors of the low portion of the bridge (neutral of the A.C. power supply) may also be performed if the thyristors are on the phase side of the power supply, more generally corresponding to a circuit with common cathodes. A structure with a diode and a capacitor is then reproduced, but from capacitor ***C2***. Capacitor ***C2*** then charges, through the additional diode, the additional capacitor having an electrode connected to terminal ***E***. The power still comes from capacitor ***C1***, but transiting through capacitor ***C2***. The modifications to be made can be deduced from the functional discussion made in relation with the previous drawings.

[50] Of course, the present invention is likely to have various alterations, modifications, and improvements which will readily occur to those skilled in the art. In particular, the dimensions given to the different capacitors and especially to the low-voltage capacitor(s) specific to the present invention depend on the application and on the expected consumptions of the control circuits. Further, although the present invention has been described in relation with the exploitation of a supply capacitor (***C1***) of the control circuit of the cut-off switch of a power converter, it more generally applies as soon as it is desired to have a low-voltage source downstream of the rectifying bridge and that a switch in the bridge or upstream thereof is desired to be controlled, with an isolation of different reference voltages. Finally, the

structure could be inverted by connecting capacitor ***C1*** on the common cathodes of the rectifying elements (diodes ***D1*** and ***D2***) and thus obtaining a negative power supply across capacitor ***C2***. The adaptations of the circuit for such an operation are within the abilities of those skilled in the art.

[51] Such alterations, modifications, and improvements are intended to be part of this disclosure, and are intended to be within the spirit and the scope of the present invention. Accordingly, the foregoing description is by way of example only and is not intended to be limiting.